METHOD OF MANUFACTURING A SCHOTTKY BARRIER RECTIFIER

CROSS-REFERENCE TO RELATED APPLICATIONS

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BACKGROUND OF THE INVENTION

Referring to FIG. **1**, a plot of the current-voltage characteristics of an exemplary p-n junction (e.g., semiconductor junction) diode and an exemplary Schottky (e.g., semiconductor-metal junction) diode, in accordance with the conventional art, is shown. It is appreciated that the plots are for illustrative purposes and do not necessary represent a particular p-n junction diode or Schottky diode. In a forward-biased state, the p-n junction diode typically has a fully conducting voltage drop of approximate 1V, for large currents. In a reverse-biased state, a leakage current, which is proportional to the junction area, flows in the p-n junction diode. The leakage current exhibits a strong temperature dependence, approximately doubling for every 10° C. rise in temperature. If the reverse-biased voltage exceeds the breakdown voltage of the device, the reverse current increases rapidly.

The leakage current characteristics and breakdown voltage of p-n junction diodes may readily be utilized in rectifier applications and the like. However, the voltage drop across the p-n junction diode during forward-biasing results in significant power consumption when relatively large currents flow through the p-n junction diode.

In a forward-biased state, the Schottky diode typically exhibits a fully conducting voltage drop of approximate 0.5V, for large currents. In a reverse-biased state, a substantial leakage current flows at relatively low reverse voltages. The Schottky diode also exhibits a weak "knee" as the device enters breakdown. Thus, the Schottky diode suffers from both a higher leakage current and a low breakdown voltage in the reverse-biased direction, as compared to a p-n junction diode.

The reduced voltage drop across the Schottky diode during forward-biasing would make the device advantageous for use in rectifier applications and other similar applications. However, the substantial leakage current and relatively low breakdown voltage limits use of the Schottky diode to low voltage applications.

Thus, in the conventional art the use of diodes, in rectifier applications and the like, suffer from higher forward voltage drop, higher leakage current and/or low breakdown voltage.

SUMMARY OF THE INVENTION

Accordingly, embodiments of the present invention are directed toward rectifiers exhibiting relatively low voltage drop when forward-biased like a Schottky diode, low leakage current when reverse-biased and a high breakdown voltage, as compared to p-n junction diodes. In one embodiment, the rectifier includes a first conductive layer and a semiconductor. The semiconductor includes a first doped region, a second doped region and a plurality of third doped regions. The second doped region is disposed between the first doped region and the first conductive layer. The plurality of third doped regions are disposed in the second doped region. The first doped region of the semiconductor is heavily doped with a first type of dopant (e.g., phosphorous or arsenic). The second doped region is moderately doped with the first type of dopant. The plurality of third doped regions are moderately to heavily doped with a second type of dopant.

In one embodiment, a method of fabricating the rectifier includes epitaxial depositing a semiconductor layer upon a substrate. The epitaxial deposited semiconductor layer has a first concentration of a first type of dopant and the substrate has a second concentration of the first type of dopant. A plurality of trenches are etched into the epitaxial deposited semiconductor layer. A portion of the epitaxial deposited semiconductor layer proximate the bottom of the trenches is implanted with a second type of dopant. A dielectric is deposited in the trenches and a first metal layer is deposited upon the epitaxial deposited semiconductor layer.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention are illustrated by way of example and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

FIG. **1** shows a plot of the current-voltage characteristics of an exemplary p-n junction (e.g., semiconductor junction) diode and a Schottky (e.g., semiconductor-metal junction) diode, in accordance with the conventional art.

FIGS. **2**A, **2**B, **3**A and **3**B show sectional views of a Schottky barrier rectifier, in accordance with embodiments of the present invention.

FIGS. **4**A, **4**B and **4**C show a flow diagram of step of a method of manufacturing a Schottky barrier rectifier, in accordance with one embodiment of the present invention.

FIG. **5**A shows an exemplary plot of the current-voltage characteristics of a depletion mode Schottky barrier rectifier, in accordance with one embodiment of the present invention.

FIG. **5**B shows an exemplary plot of the current-voltage characteristics of an enhancement mode Schottky barrier rectifier, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with these embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the scope of the invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it is understood that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the present invention.

Referring now to FIGS. **2**A, **2**B, **3**A and **3**B, sectional views of a Schottky barrier rectifier, in accordance with embodiments of the present invention, are shown. The Schottky barrier rectifier includes a semiconductor **210**, **215**, **220** and a first conductive layer **205** (e.g., anode and anode contact). The semiconductor **210**, **215**, **220** includes a first